THE GLASS INDUSTRY

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GLASS CONTAINER ASSOCIATION MEETS IN NEW YORK

The first meeting of the Glass Container Association under the presidency of George F. Lang was called to order for a two-day session at the Hotel Biltmore in New York on October 29th. During the few months which have elapsed since the Spring Meeting held in Rye, New York, problems confronting glass container manufacturers have become more complex and varied than ever before. Quite aside from the difficulties resulting from a war economy, the Glass Container Association faced the necessity of meeting under the shadow of the adverse Toledo Monopoly Trial decision which, because of its severely punitive nature, tended in itself to seriously complicate the normal approach to the complexities of wartime manufacturing, distribution and sales.

THE GLASS INDUSTRY is not in a position to report the definite conclusions of the assembled members as to whether or not an appeal would be taken to the U. S. Supreme Court from the Toledo decision. However, it can be stated that there was complete unanimity of attitude in the discussions and an announcement concerning the Association's conclusions will be forthcoming shortly.

Following the discussion of the Court Decision, the short two-day session more or less followed its usual pattern, exceptions being the introduction of problems resulting from the wartime economy.

The need for continuing work on standard testing procedures and glass research was brought to the forefront of the discussions. Such work is particularly necessary at a time when competitive packaging materials are being improved and their use extended, and these developments seem to be securing the interest not only of packers but of WPB officials due to their effect upon the conservation of metals. The industry was urged to think in terms of higher quality and lighter weight glass containers as a safeguard against post-war competition of other materials.

Victor L. Hall presented his semi-annual report of the Glass Container Association. In his introductory remarks Mr. Hall pointed out that "while the industry has been faced with many difficulties and uncertainties" since the last Association meeting he felt that comparatively speaking the glass container manufactures have been very fortunate. From a standpoint of volume of business the industry was exceeding the volume of a year ago which then represented an all-time high. Mr. Hall stated that although early in the year it was estimated that the industry should ship in the neighborhood of 80,600,000 gross, as compared with 70,000,000 gross in 1941, an increase of 15.14 per cent, this goal is not now being anticipated. Shipments probably will show a 10 per cent increase over last year.

In his report Mr. Hall touched on the vexing problems confronting the industry such as difficulties in obtaining closure materials, traffic, labor committee work, etc.

Recognition was accorded the work of the Preston Laboratories of the Standard Testing Procedure Committee, and of Bert W. Hendrickson in connection with broken bottle injury claims. In January of this year a meeting was held in New York to which representatives of the large franchise bottlers had been invited so that the work of the past few years could be brought to a practical head and some custom and usage adopted by the bottling industry. The meeting was entirely successful, with the Coca-Cola Company in particular taking a leading part in sustaining the position outlined by glass manufacturers based on their experience over the past six or seven years. Representatives of Pepsi-Cola, Coca-Cola and Canada Dry formulated a plan with their insurance carriers, which when completed will be submitted to the leading bottlers of the country.

Research on glassed foods carried on by Dr. Fellers of Massachusetts State College has proven to have value in the glass container industry's contacts in Washington. The Washington experiences have not only emphasized the need for this theoretical work but also the desirability of extensive investigation on the practical aspects of processing and handling of glass packed food products. Dr. Esselen is carrying on the work started by Dr. Fellows who is now serving in the Army.

The work of the Labor Committee and Traffic Problems were touched on very briefly by Mr. Hall in his report. Both of these factors were covered in considerable details in separate talks by Mr. Ralph Lind on labor matters and Mr. U. E. McFarland on traffic problems. A few highlights of these talks appear further on in this report.

Joseph C. Feagley submitted a detailed statement of the activities and recommendation of the War Activities Committee of the Glass Container and Closure Industries. In his report Mr. Feagley traced the work of the Committee from its inception in September 1941 when it was known as Defense Activities Committee. Its past activities are sufficiently well known to make unnecessary a detailed resume of its work. However a brief report of its recommendation based on its past experience and analysis of the problems of supply which lie ahead should be of interest.

After emphasizing again that metal and rubber for closures was still the No. 1 problem which glassmen had to face as far as packaging matters were concerned, Mr. Feagley pointed out that packers and bottlers were starting now to plan for 1943 and that normally these plans would be completed by the first of the year.

In order to avoid a "too little and too late" situation in the container fields Mr. Feagley's Committee urged the appraisal of various types of containers from a standpoint of critical materials involved and the use of a ladder table as a guide to packers in their plans to convert from one type of container to another. This, however, is based on the assumption that the Containers Branch in cooperation with the Food Supply Branch will feel that every

effort should be made to pack foods of all types as extensively as possible. Following is the table set up by the Committee:

ORDER OF CONTAINER PREFERENCE BASED ON MINIMUM USE OF CRITICAL MATERIALS

1. An all-paper, an all-glass container, or glass containers and various combinations of non-strategic materials such as paper, porcelain, et cetera.
2. A glass container with a blackplate closure.
3. A paper container with two blackplate ends.
4. A glass container with a tinplate closure.
5. A glass container with a tinplate and rubber closure.
6. An all tinplate container with rubber sealing compound.

Further reflecting the Committee's feeling with regard to the need for definite planning, precise instruction is contained in the following statement included in the report concerning orders M-104 and L-103:

"To this end we believe that the amendments revising Orders M-104 and L-103 should be issued as promptly as possible. The reissuance of M-104 in the form of a positive order will serve to indicate to packers of all types, the products for which metal and rubber may be used as closure materials. The reissuance of Order L-103 in simple layman's language, stating in the body of the Order that the Director of Industry Operations may simplify and standardize glass containers, in the exhibits showing the glass containers which have been standardized, and in the schedules indicating the exact containers which must be used for certain products, will enable present users of glass containers to switch to standard containers and aid packers converting from other containers to make the change with assurance that this problem has been studied and a definite plan worked out."

Mr. Feagley submitted the following as a guide both to glass container manufacturers and users in the development of plans and determining policies for 1943:

1. Establishment of an order of container preference.
2. Amendment of Orders M-104 and I-103.
3. An augmented personnel ir Containers Branch to aid in the administration of these orders.
4. An allocation or allotment of sufficient metal and sufficient rubber so that packers may make their plans with confidence and in turn that glass container manufacturing facilities may be used to the greatest advantage in wartime packaging.

Harry Kuni who has so ably been carrying on the Washington activities of the Glass Container Association since Mr. Carr's resignation of this post was somewhat pessimistic with regard to the immediate future for glass container production in spite of the all time high volume of business done this year. He stressed the point that the full effect of restrictive orders such as M-104 and M-119 controlling the use of closure materials has not as yet been felt. To give emphasis to this point he stated that the absolute necessity of conserving steel, tin and rubber made it certain that WPB would carefully scrutinize uses of these materials with the inevitable elimination of certain nonessential items. The reduction by 30 per cent of metal for crowns for beer and soft drinks and the complete denial of closure metal for wines and liquors were mentioned by Mr. Kuni as indicating the low degree of essentiality with which important segments of the container industry are viewed by WPB.

In connection with food packaging requirements, Mr. Kuni presented a calculation which he had made indicating that the amount of canned foods for civilians would be upward of two and a half billion units short of normal of the 1942-43 season.

He stated that while the WPB has a very fair conception of the work involved, no clear policy has as yet been evolved which would put an end to the confusion which exists within both the packing and container industries. This confusion is strongly evidenced by the growing sentiment for a "Food Czar."

Mr. Kuni concluded his address by urging the industry to emphasize those types of ware used for food packing, and he felt that the industry's ability to hold its present level of production would depend to a large extent upon their success in this direction.

Edward J. Detgen, Chief, Specialties Staff, U. S. Department of Commerce, gave the glass men a talk which was not only interesting but unusual in that he did *not* talk "off the record."

"We think it is generally agreed," Mr. Detgen said, "that substantial savings of steel and tin are achieved by the substitution of glass for metal containers. As evidence of this belief we can point to a number of products which have already been shifted from metal to glass containers, such as paint, beer, syrups, polishes, and many others. While no figures are available as to the extent of this substitution, we estimate that in the neighborhood of 10 billion cans are being eliminated from the packaging field and that glass containers are taking over a good portion of this volume. It is true that many of the products which have been denied metal containers have also been denied metal closures. It is also true that uncertainty exists concerning the availability of metal closures for borderline products which have not yet been denied metal. However, this situation will soon be clarified so that manufacturers and users of glass containers and closures will have a definite basis for determinations.

"Despite the great economies that already have been effected in the use of critical materials by the container industries, intensive efforts are underway to further economize. In this connection, glass containers are being studied from two angles. First, to restrict the use of rubber and metal in closures wherever such restrictions can be applied without eliminating the packaging of essential products; and secondly, to find ways and means of using the excess capacity available in the glass container industry to package essential products now permitted metal containers."

In another part of his talk Mr. Detgen stated: "To put it bluntly, we are aware of the savings that can be achieved by the maximum utilization of glass if certain basic difficulties can be solved. It is your responsibility to contribute to their solution. When I tell you that by licking these problems we can visualize a saving of a half million tons of steel and about five thousand tons of tin, with no reduction in the number of available containers, you will appreciate, I am sure, the significance of your assignment."

Dr. Frank W. Preston spoke to the glassmen about the glass research program, pointing out that research seemed about the only thing Judge Kloeb really approved in his recent decision, that is, so far as the Association was concerned. Dr. Preston urged the spending of more

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THE ADHERENCE OF GLASS TO METALS

R. M. KING*

Glass-to-metal adherence is important in the sealing of metal filaments in electric light bulbs, in the sticking of glass to molds, in the metal coating of glass for mirrors and other purposes, and in the application of vitreous or "porcelain" enamels to metals. A discussion of possible cause of the phenomena seems appropriate.

In his excellent article on the influence of "oxygen bonds" and "residual valences", Weyl[1] has suggested much for thought and experiment regarding glass-to-metal adherence, and has offered a plausible general theory for this phenomenon. Several statements, however, require confirming references or confirming experimental evidence, particularly those relating to the influence of cobalt oxide upon the adherence of enamel ground coats to sheet steel which seems to be a special case. Also, it is not clear what is meant by "residual valences" and "oxygen bonds", and some discrepancies seem to exist in regard to conceptions of the fine structure of glass as determined by X-rays on one hand and absorption spectra on the other.

The term "residual bond" usually refers to the Van der Waal's bond which, though present to a degree in most solids, is very weak and hence could not account for a substantial portion of the glass-to-metal bond strength. Also, in the surfaces of all solids and liquids certain unbalanced forces exist which give rise to surface tension and adhesion tension and with which are associated the so-called wetting properties of solids and liquids. Such forces, however, have not been shown to account for the marked adherence of ground enamels containing cobalt. It is conceivable also that bonds may develop from attraction between ions and dipoles and ions and induced dipoles, but here again we know little about such forces in glass-metal combinations.

As to "oxygen bonds", Weyl no doubt has in mind the singly bonded oxygens proposed by Warren[2]. The origin and presence of these bonds will be better understood from a summary of the work of Zacharaisen[3], and Warren and coworkers[2].

1. Oxides such as SiO_2, B_2O_3, P_2O_5, and others form glasses alone and must be present in minimum proportions in all glasses. These oxides are known as network formers and each cation is surrounded by three or four oxygen atoms at the corners of triangles or tetrahedra—a single oxygen at each corner. The charges on the cations are high, the cation radii and cation-oxygen distances are small, and hence the cation-oxygen attraction is high. The radius ration of cation to oxygen ranges from 0.15 for B_2O_3 to 0.46 for Sb_2O_5. With two possible minor exceptions silicon is always surrounded by four anions and boron, except in special cases is surrounded by three anions. Thus these cations are said to have tetrahedral (fourfold) and triangular (threefold) coordination.

2. Cations such as those of the alkalies and alkaline earths are called network modifying cations because their oxygen becomes a part of the network by breaking some of the oxygen bonds thus producing the singly bonded oxygens referred to above. These oxygens have a single unsaturated valence for which the network forming cations and network modifiers compete. The latter must take second choice in this competition because of lower bond strength arising from lower charge and larger radii. Hence the network formers maintain the same coordination as they possess in crystals, and while the same tendency persists with respect to the modifiers the net result is a statistical grouping of oxygens about the modifying cation. On the average the number of oxygens about the cation is that found in the crystalline state, but the presence of the crystal grouping in glass is merely accidental. According to Zacharaisen[3] no two atoms in a glass are structurally equivalent.

3. Beryllium oxide and aluminum oxide, according to Sun and Silverman[4], may act both as network formers and network modifiers. Beryllium, as far as is known, always has fourfold coordination. Aluminum in the presence of alkalies and alkaline earths may have both sixfold and fourfold coordination even in the same crystal.

Oxygen Bonds and Adherence

Assuming that the singly bonded oxygens in the glass structure contribute to adherence, how they function is not apparent. If one might speculate it would seem that these free oxygen valences would tend to oxidize the surface of the metal and the metal oxide would become a part of the glass. Then more oxygen bonds would form and this cycle would continue until an equilibrium is reached at which crystallization of the metal oxide would probably take place. If diffusion into the glass is not rapid, crystal formation might occur quickly. The crystals formed might act as a cementing layer between the glass and the metal.

Also, the oxygen bonds might attract the metal atoms and in this manner produce a degree of adherence. So little is known, however,, regarding this possibility that speculation here is premature.

Coordination of Cobalt in Glass

In considering the coordination of cobalt in glass, Weyl[1] states:—

> "Only cobalt glasses where cobalt ion takes the place of silicon forming CoO_4 tetrahedra possess the quality of adhering to iron. Pink cobalt glasses where the absorption spectrum reveals the presence of CoO_6 groups do not exhibit the same quality."

Tetrahedral coordination of cobalt in glass has not been established by X-ray methods so far as this writer can determine. This element does not satisfy the chief

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criterion established for such coordination in glass, namely a limiting cation-oxygen radius ratio. None of the network forming or intermediate oxides have a cation-oxygen ratio above 0.46 with the exception of As_2O_3 (0.51) and Sb_2O_3 (0.66) which are special cases. Values for the two cobalt ions are: Co^{++} : 0=0.62 and Co^{+++} : 0=0.50. According to Weyl[5] cobalt does not change its valence in glass, hence only the first value applies here.

It is true that cobalt in the compound $CoAl_2O_4$ has fourfold coordination, but so does magnesium, iron, and nickel in the compounds $MgAl_2O_4$, $FeAl_2O_4$ and $NiAl_2O_4$. In silicates such as olivine, however, magnesium and iron have sixfold coordination.[6] The coordination of cobalt in silicates has not been determined, but from analogy with the olivines and pyroxenes, and the close agreement in size of their radii and similarity of other properties of magnesium, iron, nickel, and cobalt it is a reasonable assumption that the coordination cobalt ion in silicates is sixfold. In a ground enamel, therefore, where the silica content averages about 50 per cent and the alumina only about 7 per cent it would appear that any tendency toward crystal coordination would result in formation of CoO_6 groups.

Dietzel [7] has presented the same analogy in regard to groups occurring in glass and crystals and has differentiated between two types of changes in the coordination of cations in glass: (1) A change from a saturated to a lower unsaturated coordination, and (2) a change from a higher saturated coordination to a lower saturated coordination. As examples of the first type he cited the copper ion as having both four and sixfold coordination in glass as well as a middle condition in which two of the oxygens are at a greater distance from the copper ion than the other four. Lead was also represented as changing its coordination in glass as well as in crystals. Iron, nickel, and cobalt ions were given as examples of the second type and it was stated that the binding in CoO_4 groups is covalent and saturated. According to Weyl[8] these groups are blue in color and unsaturated.

It seems important to emphasize the word *tendency*, for if many CoO_6 groups should form crystals of a cobalt compound might appear. The first indication, however, of successful competition on the part of cobalt to obtain its full quota of oxygen atoms would be the formation of immiscible liquid phases. Grieg[9] has shown that cobalt oxide-silica melts along with similar melts of CaO, BaO, and MgO exhibit liquid immiscibility within certain composition ranges. The cations of these oxides have coordination numbers ranging from 6 to 8. It is quite likely, therefore, that cobalt has a tendency to form CoO_6 groups in such melts.

Warren and Pincus[10] based their plausible theory of immiscibility on the assumption "that the atomic arrangement in a glass melt is roughly the same as in the glass except for the obvious difference that in the melt bonds are continually breaking and forming." In the light of this assumption it is difficult to reconcile the presence of "blue CoO_4 groups" and "pink CoO_6 groups" with known color changes in some cobalt glasses. These glasses are blue when hot and pink when cold, thus indicating a greater ability of cobalt to attract ions on cooling than in the hot melt if a pink color is characteristic of CoO_6 groups.

This brings us to a consideration of the relation between the color of cobalt compounds and the coordination of the cobalt ion. A difference of opinion seems to exist among investigators as to whether CoX_4 groups are responsible for blue colors and CoX_6 groups are responsible for pink colors even in solutions and crystalline compounds. Kiss, Csokan, and Richter[11] state; "On the basis of a great deal of experimental material the assumption is refuted that all red cobaltous complexes have coordination number six and all blue ones have coordination number four."

It is true that cobalt in the compound $CoAl_2O_4$[12] has the coordination number four and the color is blue, and that the cobalt ion in the compound Co_2SiO_4 has by analogy with the olivines the coordination number six and varies in color from red to violet[13]. In the compound Co_2CoO_4 cobalt has both four and sixfold coordination and the color is black. Also, the color of Co_2MgO_4[13] is black and the coordination of cobalt is sixfold while solid solutions of CoO and MgO are rose colored and the coordination number of both cations is six.

Again solid solutions containing 30 per cent CoO and 70 per cent ZnO are green and those containing 70 per cent CoO and 30 per cent ZnO are rose colored[12] and the coordination numbers are six and four respectively. The spinel ($CoZnO_4$) has a darker green color and the coordination number of cobalt is six and of zinc four.

According to Grieg[9] a cobalt-silica glass containing 10 per cent cobalt oxide exhibits liquid immiscibility and is blue. By analogy with calcium, barium, and magnesium glasses the coordination tendency of cobalt is sixfold.

Coordination of Cobalt and Adherence

Assuming that cobalt does occur in ground enamels in fourfold coordination, let us examine the statement that such coordination is responsible for adherence. If true, then other cations having fourfold coordination also should promote adherence. Silicon is the most persistent in maintaining fourfold coordination in glass and crystals and ground enamels contain on the average about 50 per cent silica. On the basis of fourfold coordination, therefore, this amount of silica should bring about more adherence than 0.8 per cent cobalt oxide, but this is not the case. Furthermore, in the presence of alkalies and alkaline earths some boron and aluminum ions are likely to have fourfold coordination. The average B_2O_3 and Al_2O_3 contents of ground coats are 14 per cent and 7 per cent respectively, but no enamel technologist would agree that these compounds would be satisfactory substitutes for cobalt oxide.

According to Dietzel[7] iron, copper, and nickel also occur in fourfold coordination in glass. If the analogy between glass structure and crystal structure holds for these elements and cobalt, it no doubt holds for magnesium. None of these elements except nickel approach the adherence promoting properties of cobalt.

Furthermore, ground coats contain about 4 per cent of fluorspar. According to Weyl's[1] plausible theory the substitution of fluorine for oxygen in a glass reduces the adherence. Hence the presence of fluorine in the enamel would partially, at least, offset the influence of any possible CoO_4 groups.

Again, if we attribute adherence to the free valence of singly bonded oxygens we must assign part of the credit for this adherence to the network modifying oxides for they are a co-author of the free oxygn bonds. The network formers have the bonds and the modifiers break them. One might, therefore, be inclined to give the greater part of the credit to the modifiers, and to assign greater adherence promoting powers to cobalt as a modifier than to cobalt as a possible network former.

The above given statements lead one to conclude that if CoO_4 groups are present in cobalt ground coats their influence upon adherence is insignificant.

Color of Cobalt Glasses and Adherence

In order to check the statement that blue but not pink cobalt glasses exhibit the property of adherence some experiments were performed, the results of which are given in the following table:

Glass Composition	*Color Hot*	*Color Cold*	*Adherence*
99.2 B_2O_3-0.8 Co_3O_4	Blue	Reddish violet	Fair
12.9 Na_2O-87.3 B_2O_3-0.8 Co_3O_4	Blue	Purple	Good
6.3 Na_2O-92.9 B_2O_3-0.8 Co_3O_4	Blue	Red violet	Good
30.8 Na_2O-68.4 B_2O_3-0.8 Co_3O_4	Blue	Blue	Good
99.2 BeF_2-0.8 Co_3O_4	Lt. Blue	Lt. Blue	Good
24.1 Na_2O-34.7 B_2O_3-40.4 SiO_2 0.8 Co_3O_4	Blue	Blue	Good
98.7 BeF_2-1.3 $CoCl_2$	Pink	Pink	Fair

Admittedly, methods for determining adherence of these glasses were crude since no accurate methods were available. Also, compositions of glasses were different from enamels, and because of their solubility could not be applied by usual methods. Hence a special technique was used. It is significant, however, that in all tests the greater part of the area of break occurred within the glass, and in some tests all of the break occurred within the glass rather than between the glass and the metal. The statement that pink glasses will not adhere to steel is not therefore confirmed.

Furthermore, it will be noted that even beryllium fluoride glasses had "substantial adherence to the iron. This is significant in the light of the role assigned to free oxygen bonds and in the light of statements that when fluorine is substituted for oxygen free bonds are not formed and adherence is reduced.

Oxide Theory of Enamel Adherence Inadequate

The traditional theory of enamel ground coat adherence is known as the oxide theory and is based upon the presence of iron oxide at the enamel-iron interface. Spencer-Strong and King[14] found, however, that when enamels were fired under such conditions that equilibrium was attained between the phases at the interface, no iron oxide was to be found, and yet adherence was good. This suggested that the oxide phase found when enamels were fired under commercial conditions is not necessary for adherence.

It is probably not a coincidence that the protoxides of the two most easily enameled metals, iron and copper, have peculiar properties. Some doubt exists as to whether the oxide FeO can be prepared. A range of solid solutions, however, does exist in which all compositions are lower in iron than theoretical FeO. These solid solutions are unstable, however, below 575° C., at which temperature they decompose into iron and Fe_3O_4.[15] The fact that "FeO" is unstable at room temperature and that Fe_3O_4 is soluble in ground enamels renders the oxide theory of adherence untenable.

No intensive research has been done on the adherence of enamels to copper, but Cu_2O has a structure which "can be regarded as an interstitial solution of oxygen in the metallic copper lattice".[16] This suggests the possibility of a linkage between oxygen in the enamel and copper which might account partially for the adherence of enamels to copper.

Action of Cobalt in Ground Coat Enamels

According to Weyl "The phenomenon of glass-to-metal adherence is very complex and cannot be covered by a single explanation." If by "single explanation" is meant a general explanation, this statement applies particularly to the action of cobalt in enamel ground coats. Enamel technologists have sought for years for an explanation of the action of cobalt but no general explanation has been found satisfactory. So it has become necessary to search for some specific action of cobalt.

Reference was made above to the possibility of a crystal phase forming at the enamel-metal interface and acting as a bonding agent. Attention was also called to the fact that because of the decomposition of "FeO" at low temperatures Fe_3O_4, Fe and possibly "FeO" may be present at the interface. Further, it was mentioned that under equilibrium conditions only Fe has been found but adherence remained good. Iron found under such conditions has a dendritic or tree-like structure. These dendrites are always present when adherence is good and absent when adherence is bad. It has been found that cobalt aids in their formation.[17] That they play a primary role in the marked adherence of cobalt ground coats to steel is supported by an array of evidence which has not been successfully contradicted. Admittedly "oxygen bonds" and "residual valencies" from any source may play a secondary role but adherence from these sources is probably not unique with respect to cobalt.

Adherence of Glass to Molds

In the light of the conditions existing in glass molds during forming operations, as described by Dierker,[18] it is entirely possible for dendritic adherence to be a factor in the sticking of glass to molds. The possibility should be worth investigation.

Summary

The basis for Weyl's plausible theory of adherence through "oxygen bonds," which seems to be applicable to glass-to-metal adherence in general, has been discussed. Some discrepancies as to the source of these bonds and as to ionic groupings in glass as revealed by X-ray and absorption spectra technique have been pointed out.

Evidence relating to theories for the adherence of cobalt-bearing-ground enamels to sheet steel have been reviewed. It has been emphasized that although some of the adherence of these enamels may be attributed to

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NEW ANNEALING TECHNIQUE IN OPTICAL GLASS PRODUCES GREATEST HOMOGENITY

Fig. 1. Glass technologists know that the density, refractive index, and other properties of glass vary with the degree of annealing. A new scientifically controlled process of heat-treating optical glass developed by Dr. E. D. Tillyer, research director of American Optical Company, produces maximum density, compacted glass that is perfectly homogeneous throughout its entire structure directly and quickly without relying on trial and error. This optical uniformity simplifies the mass grinding and polishing of precision optics and prisms. The process also stabilizes the glass so that future changes in its performance do not take place with age. As shown above, first step in developing the new process was drawing small chilled glass specimens for thermal expansion testing.

Fig. 2. The glass specimen was then placed in a Dilatometer, instrument used to record the changes in length of glass and metals under heat treatment. Heat was gradually increased in the furnace chamber of the instrument to just below the known softening point of the specimen. By means of a beam of light and a photographic attachment, a greatly magnified record of the difference in the expansions of the specimen against a standard was continuously photographed. Above, Dr. Tillyer (left) supervises the adjustment by B. J. Ziegler of the Dilatometer prior to the running of the test.

Fig. 3. Here you see Dr. Tillyer and John K. Davis translating the film into another graph to obtain the expansion coefficient of the glass at different temperatures. As a result of his laboratory tests and calculation, Dr. Tillyer discovered the best time-temperature cycle which accomplishes two objectives: the removal of birefringence strain from the glass, the previously known step; and also a thorough packing and settling of the atomic structure of the glass during annealing to maximum density.

Fig. 4. To prove the new theory of heat-treatment, electrically heated "thimble" furnaces were built. In these furnaces tiny pieces of glass for refractive index measurements were maintained around the critical temperature range as indicated on the expansion chart shown in picture 3. Above, Dr. Tillyer examines a specimen from a previous run while W. B. Reed checks the temperature in the other furnaces. Samples held at the temperatures selected from the chart were proved to reach maximum refractive index in the shortest time.

Fig. 5. Close-up of the tiny glass samples annealed during the development of this new technique of heat-treating optical glass. The new process permits the manufacture of precision lenses and prisms that do not have to be reannealed or hand corrected, and that do not lose their accuracy with age.

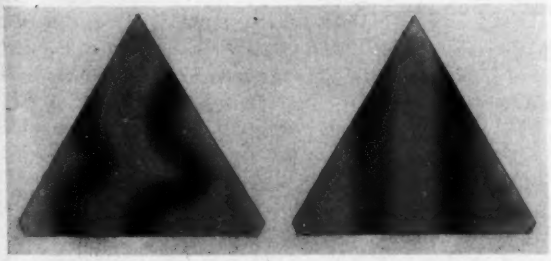


Fig. 6. The above picture demonstrates scientifically the value of the new heat-treating process. The prism at the left, as seen through an interferometer, is a typical result, often obtained with old forms of annealing. The curved lines indicate refractive index (light-bending power) of the glass was not constant throughout. The prism at the right is properly heat-treated by the new technique. The straight lines show that the glass is homogeneous throughout its entirety, indicating that maximum packing (index of refraction) has been reached.

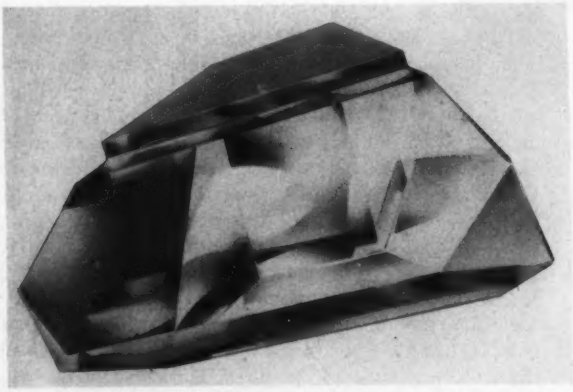


Fig. 7. Here's an end result of Dr. Tillyer's new method of annealing optical glass—an essential and difficult roof prism, to be used in a precision instrument. Development of the new process is highly significant because it eliminates production delays and rejections previously encountered in manufacturing complex prisms and precision lens systems for which there is in urgent military demand.

THE DEVELOPMENT OF LOW MELTING GLASSES ON THE BASIS OF STRUCTURAL CONSIDERATIONS

By NORBERT J. KREIDL[1]* and WOLDEMAR A. WEYL*

PART III

LIMITING FACTORS OF STRUCTURAL CHANGES

Introduction

In the preceding chapter the structural changes have been described which improve the meltability of a glass. The practical methods used for this purpose as a rule involve several of these structural changes simultaneously. Only by a combination the maximum effect can be obtained: for, the degree to which any one of these changes can be applied is limited. The weakening of the glass structure resulting either from the change in the geometrical configuration or the diminution of interatomic forces unfortunately causes a certain instability of the glass which favors devitrification and chemical disintegration. From a general viewpoint, the following limitations have to be considered if one of these structural changes is carried too far:

(a) devitrification
(b) immiscibility
(c) volatility
(d) chemical attack

(a) Devitrification

Devitrification as a limitation of structural changes has been encountered in the previous discussions when excessive amounts of a basic oxide like CaO were considered as an addition causing an increased oxygen ratio. The more we approach the oxygen ratio of ortho, or even metasilicates, the less chance we have to maintain the glassy character on cooling. But even in the more secure composition fields of the more acidic commercial glasses the necessity of holding the glass for considerable time at a working temperature, which favors crystallization may cause devitrification. Molding and working operations which expose the glass for a longer time to this dangerous temperature range, like the drawing processes of the window glass, may encourage devitrification in glass compositions which appear safe under other manufacturing conditions.

Absolute security against devitrification is only warranted, if the liquidus temperature of the glass composition is lower than the working temperature. According to this severe condition the temperature corresponding to the relatively viscous working range must be higher than the liquidus temperature above which no crystalline phase is stable.

We are not able to calculate the liquidus temperature from the composition and even if such a formula would exist for simple systems it would hardly be applicable to the problems of glass technology. However, many typical influences on devitrification can be fairly well gathered from the growing information available on the liquidus curves of simple glass forming systems. The best collection of this information is compiled in *"Properties of Glass,"* by G. W. Morey, who participated in the establishment of the most important equilibria. As a rule, more complicated than ternary systems are not at our disposal, although some interesting excursions into the more complex fields have been made. Certain fields of devitrification remain qualitatively similar if minor quantities of further components are added, so that conclusions from ternary systems can be drawn for more complex systems. Moreover, as a rule, the probability of devitrification decreases with the addition of further components, and lower eutectic temperatures are encountered. This allows us to say that suitable ternary compositions provide starting points and indicate the expected limitations for multicomponent melts devised according to the various principles to decrease the melting temperature.

This consideration definitely limits the use of calcium oxide which does not influence meltability in a specific way but represents a desirable constituent promoting chemical stability. The liquidus temperatures and the phases crystallizing in the soda-lime silica field have been accurately established by G. W. Morey and other members of the Geophysical Laboratory in Washington. In Morey's book on the properties of glass we find an ample discussion of this subject. The addition of CaO beyond the usual amounts of about 20 per cent in soda lime glasses rapidly increases the devitrification tendency, although the crystals observed are not always those postulated by the equilibrium diagram.

For eliminating these devitrifications the introduction of small amounts of MgO, Al_2O_3 and B_2O_3 was particularly successful. Morey's representation of the very low liquidus temperature caused by 2-3 wt. % MgO in a soda-lime-silicate glass is illustrative of the probable influence of similar additions of MgO to other and more complex silicate glasses. An example of Morey's results is the addition of 2.5% MgO to the glass containing 14.86% NaO_2, 9.83% CaO, and 75.15% SiO_2, which decreases the liquidus temperature by 200°C.

The similar influence of small amounts of alumina was studied by the same author. 2% Al_2O_3 replacing CaO caused a drop of the liquidus temperature by 80°C in a glass containing 14.3 Na_2O, 11 CaO, and 74.7 SiO_2.

B_2O_3 lowers the liquidus temperature considerably only if the glass is very high in SiO_2.

Even though conclusions drawn from simple systems obviously have to be applied with caution, the study of these fundamental effects is responsible for many successful approaches in practical glass melting, where "beautiful" devitrification samples become more and more a rarity. Similarly, Al_2O_3 and B_2O_3 will always be found useful in the development of new low melting glasses whenever devitrification threatens.

The use of lithium oxide which according to our previous discussion, represents a very powerful flux, is chiefly limited by its tendency to promote devitrification. Consequently, it is mainly used in combination with the other alkali oxides and rarely exceeds one-fifth of the

total alkali content. The use of potassium oxide, on the other hand, is a convenient way to decrease this tendency.

In order to avoid the crystallization in soda-lime glass melts the replacement of smaller amounts of CaO by PbO has been found helpful.

The use of fluorides as fluxes is severely limited because fluorine does not only increase the crystallization of silica and silicates, but also participates in the formation of various crystalline fluorides. For fluxing purposes it is not safe to exceed the use of 2-3% fluorine in soda-lime glasses.

Only in rare cases is it possible to achieve the ideal non-devitrifying glass by lowering the liquidus temperature below the working range. But this absolute guaranty against devitrification is not necessary, if we succeed only in reducing the speed of crystallization in the working range so that crystallization is practically impossible. The speed of crystallization of different glasses varies considerably. Certain melts such as lithium or calcium silicates require rapid chilling in order to remain in the vitreous state, whereas pure potassium silicates have to be treated for months at favorable temperature before devitrification is noticeable. Influencing the speed of crystallization is the most common way of preventing devitrification of commercial glasses.

Alumina and boric acid do not only lower the liquidus temperature but also decrease the speed of cystallization, and, as is known, prevent devitrification in technical glasses. The reason can be seen easily from the following structural considerations. The network modifying ions such as Ca, Ba, or Li are very mobile in glasses down to low temperature. They are known to migrate through the rigid glass network when an electric field is applied. The network forming ions silicon, boron, and aluminum, on the other hand, are interlinked by strong chemical forces and are not very mobile when the glass has reached the relatively high viscosity of the working range. The formation of a devitrification product, for instance, calcium melasilicate, in a pure soda-lime-silicate glass is relatively probably, because the mobile calcium ions have just to diffuse into a certain volume element where they replace the sodium ions, which are very mobile, too. The silica network has to undergo only a slight geometrical change because no $Si\text{-}O_4$ tetrahedra have to be removed from this volume element. The same process in a borosilicate or alumisilicate glass is considerably more involved. Although the adjustment of the calcium and sodium ions can again take place with the same velocity, the formation of the crystal lattice of wollastonite ($CaSiO_3$) now would require the removal of $Al\text{-}O_4$ or $B\text{-}O_4$ units or their replacement by $Si\text{-}O_4$ units. This latter process involves reactions of the high activating energy which corresponds to the breakage of the strong Si-O and Al-O bonds. Consequently, it requires more time. In this way the introduction of ions other than silicon which participate in the network proper decrease the speed of crystallization of silica and silicates. Even crystallization of alumosilicates such as nepheline is a slow process because the rearrangement of $Al\text{-}O_4$ and $Si\text{-}O_4$ units necessitates the breakage of many Al-O and Si-O bonds.

From experience it is known that molten feldspars are extremely difficult to crystallize; for, in this case the crystallization process involves the moving of $Al\text{-}O_4$ and $Si\text{-}O_4$ units from their statistical positions into the places required by the symmetry of the crystal. The same mechanism would have to take place in an aluminum containing glass.

(b) Immiscibility

The phenomenon of immiscibility has been studied repeatedly. It is relatively common in binary systems, but usually the addition of further components rapidly closes the immiscibility gap. From this point of view, immiscibility is a serious limitation only for glasses of the vitreous silica type, if their melting point is to be lowered by additions of a divalent modifying oxide. Immiscibility occurs when CaO is added to fused silica. The immiscibility between CaO and SiO_2 rapidly decreases when small amounts of Al_2O_3 are added. In the same way small amounts of alkali are sufficient to destroy the immiscibility existent between CaO and B_2O_3. Avoiding immiscibility in the development of glasses is, therefore, even simpler than avoiding devitrification. Applying different structural changes simultaneously leads to multi-component glasses, where immiscibility does not occur.

(c) Volatility

The fifth of the structural changes discussed was based on replacing part of the oxygen by fluorine or chlorine. By such a replacement, the sum of the valencies of the glass constituents is decreased and the melting range lowered accordingly. This change leads soon to another limitation besides crystallization. The more oxygen we replace by fluorine, the more probable becomes a configuration of the type $Si\text{-}F_4$ where the valencies are saturated within the tetrahedron. A $Si\text{-}F_4$ group, therefore, does not act any more as a structural unit, which can be interlinked with other similar units, forming a three-dimensional network. Si bound to four F represents a molecule silicon tetrafluoride, and can easily volatalize from the melt causing a loss of both fluorine and silicon. Some other fluorides forming in the melt, such as the alkali fluorides may also volatalize. The limitation imposed upon glass compositions by the volatility of fluorides has been exaggerated in the past, but it is still serious enough to be considered whenever fluorine is used in excessive amounts. How much fluorine a glass can stand depends upon its composition. Glasses high in Al_2O_3 and P_2O_5 seem to be able to retain fluorine in the melt under conditions where pure silicate glasses show a considerable fluorine loss.

Chlorides, bromides, and iodides have such a high vapor pressure that they cannot be introduced easily into high melting glasses. In low melting glasses and enamels, however, halides offer another possibility for lowering the melting temperature and here the immiscibility might be considered more of a restriction than the volatility.

(d) Chemical Instability

The weakening of the structure which results in the desired lowering of the melting temperature will frequently impair the chemical resistivity.

The successful development of low melting resistive

glasses would be impossible, if the chemical resistivity and the structural strength were completely parallel. Fortunately, this is not always the case. The ordinary soda-lime glasses possess a much higher chemical restivity than the sodium silicate glasses of the same meltability and corresponding structural strength. The earliest commercial glasses were based on this specific use of calcium oxide. Similarly soft sodium borosilicate glasses are fairly stable if compared to the water soluble water glass of equal melting behavior. It is true that the structural strength contributes to the chemical stability; thus the addition of Al_2O_3 increases both the structural strength and the chemical resistance of silicate and phosphate glasses. Nevertheless, the preceding examples as well as a closer investigation of the mechanism of chemical attack shows that the influence of the glass composition on the chemical resistivity is by far too complicated to permit an explanation on the basis of simplified structural principles alone.

The chemical nature of the attacking medium introduces many variables. The attacking medium can be liquid or gaseous; solutions can be neutral, acidic, or alkaline; they may contain numerous ions capable of specific chemical reactions with the glass, such as fluorides and phosphates. The concentration of the reaction product increases constantly if the attack is caused by the action of the content of a container. On the other hand a window glass is attacked by rain under different conditions, because the reaction product is continuously removed. In all cases the reactions take place at the surface, which often becomes more or less hydrated and behaves quite differently when compared with the bulk of the glass. But in each of these cases, the mechanism of chemical attack is different. The problem of developing a glass of high resistance has a definite significance only if the attack is specified. Nothing short of a treatment under closely simulated service conditions is a fair test of the required resistivity. This being the case, it is not possible to specify theoretical rules concerning the composition of a low melting glass of something like a "good chemical resistivity." One can, however, apply the present knowledge of the mechanism of chemical attack in combination with the empirical data on the influence of glass composition on resistivity under various conditions.

A convenient classification of chemical attack is again provided by the consideration of the two possible positions of the positive ions in the glass. The network forming ions like silicon and the network modifying ions like sodium are bonded to their oxygen neighbors in a different way. This has been amplified in the foregoing section on structural changes leading to lower melting temperatures; but for the problem of chemical attack one obvious consequence of the "hole" position of the sodium type is significant. The ions in this position maintain their ionic character. On the other hand, the silicon oxygen bond is sufficiently strong to make the ionic nature of silicon negligeable for all problems arising outside of its oxygen tetrahedron: the $Si\text{-}O_4$ group acts as a chemical individual, that is, as the complex anionic group SiO_4^{4-}. Having this in mind, we may differentiate between the following two types of attack:

(1) The modifier ion (Na^+) is exchanged with hydrogen ions from the attacking medium. In this case, the $Si\text{-}O_4$ structure of the glass surface is not destroyed, but changes in composition by the constant exchange of modifier ions and is finally converted into a hydrated silica gel. This composition change lowers the refractive index so that interference colors result, the order of which permits an estimate of the thickness of this hydrated layer, that is, of the depth of attack. This form of attack is typical of the action of acids except hydrofluoric acid.

(2) The continuity of the $Si\text{-}O_4$ tetrahedra is interrupted. This form of attack results in the complete corrosion of the glass. But now the uppermost layer of the glass is dissolved completely, a new surface of identical composition is created, and, consequently, no interference colors appear. We expect this second mechanism of attack whenever the attacking medium forms soluble compounds with silica. Hydrofluoric acid and alkali are two examples. For the latter case, Geffken and Berger have given a complete explanation on a structural basis.

The alkali ions and the OH^- ions from the solution are first absorbed at the locations of Si-O-Si bridges in the surface of the silica network, which they finally disrupt. As soon as all four oxygens surrounding a silicon have been separated from the adjacent $Si\text{-}O_4$ tetrahedra, the resulting $Si\text{-}O_4$ island is detached and enters the solution. The complete reaction requires two Na^+ per silicon. Fig. 8 shows the disruption of one oxygen bridge:

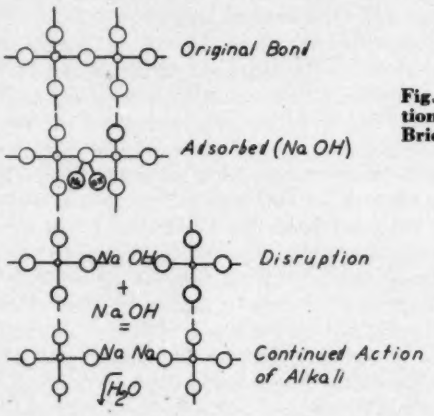


Fig. 8. Disruption of Si-O-Si Bridges.

The very fact that adsorption is a primary step in this particular mechanism of chemical attack explains that the influence of glass composition on chemical resistivity must be very different from that on strength and meltability. The adsorption, for instance, of Na^+ or OH^- ions from the solution will be individually favored or discouraged by the various elements introduced into the glass. The solubility of all reaction products formed in the liquid attacking medium is another decisive factor. We may summarize that the influence of the glass composition on the chemical resistivity is by far more diversified than that on meltability.

This does not mean that the research worker has to develop his low melting glass without knowing anything about its chemical properties before he has exposed it to a service test. Some experience is available with respect to the influence of the incorporation of oxides such as Al_2O_3, CaO, BaO, ZrO_2, TiO_2 on the resistivity towards alkaline, neutral and acid attack, which makes it possible to balance low melting glasses accordingly.

(*Continued on page 441*)

PRODUCTION OF OPTICAL GLASS IN AUSTRALIA*

By PROF. E. J. HARTUNG
University of Melbourne

The manufacture of optical instruments of many kinds for the Armed Forces has become an important section of the extensive program of munitions production undertaken by Australia in the present emergency. Of necessity, a new and complex industry of this type had to cope with many initial problems, among which the supply of suitable optical glass soon began to cause anxiety. Some glass was obtained from Great Britain and the United States, but in the dark months following the capitulation of France optical glass of good quality and in sufficient quantity was not obtainable. In certain directions, the need became so great that spectacle lenses were used, and blocks of glass for the prisms of tank periscope had to be made by welding together many sheets of plate glass.

The decision to undertake the production of optical glass in Australia was made in the latter half of 1940, and subsequent events have shown most thoroughly the wisdom of this policy. About fourteen months after the first experimental work was initiated, full-scale production of glass of admirable quality commenced and has continued uninterruptedly, so that Australia is now not only completely independent of external supplies but is even exporting optical glass to other countries. This achievement has been due to close co-operation between the Chemistry Department of the University of Melbourne and the technical staff and facilities of Messrs. Australian Consolidated Industries Ltd., to which organization the actual production of the glass was entrusted. It is also a pleasure to record the very willing assistance received from the staff of the National Bureau of Standards, Washington, who placed freely at our disposal their extensive knowledge of technical details, thereby saving us much valuable time.

The original program called for the production of six standard types of optical glass; this number was afterwards reduced to four which are now in production, but all six were made successfully in the laboratory. There were two main problems: (a) suitable raw materials for the glasses; and (b) suitable fire-clays for the pots. Fortunately, excellent sand was available in quantity, being in regular use for making flint glass for table ware. This sand contains less than 0.01 per cent iron oxides and the optical glasses made from it have proved to be almost ideal in regard to freedom from color and turbidity. Other raw materials of high purity were soon located and removed further anxiety in this respect. The main experimental investigation was therefore directed to the selection of suitable pot-clays. About eighty specimens from various parts of Australia were examined as to refractoriness under load shrinkage, chemical composition, especially iron and titanium content, texture and workability. From these about ten clays were selected for further trial; these were suitably blended and fashioned into small open pots holding about 2 lb. of glass each. These pots were fired in a small gas furnace and the glass batch introduced through a silica tube into the pot at 1,400° C. until the glass was in quiet fusion. After stirring with a silica rod, the pot was heated at a steady temperature (usually 1,450° C.) for 12 hours, cooled down, cracked open and the glass examined for pot contamination.

In such small pots, it was, of course, impossible to make optically homogeneous glass, but the resistance of the clays to glass attack and their general quality under the severe test conditions could be readily ascertained. It was felt that the results of these tests could be applied to the construction of suitable large pots with safety, owing to the better volume-surface ratio in the latter and the lower and more controllable temperature to which they would be exposed. These expectations were realized, and it was also found possible to slip-cast the large pots and dry them ready for the pot arch in about six weeks. As these pots can be raised to the temperature of the melting furnace in 4½ days, a great saving in time is thereby accomplished.

The pot-making and optical glass annexes have been very simply constructed to facilitate handling and reduce labor to a minimum. The capacity of the former is amply sufficient to maintain a supply of pots for a one-day melting schedule for the glass, which in turn reduces shift problems and operating costs, while the pot-handling and the stirring equipment is simple and efficient. After inspection of the chunks of glass from the pot, they are softened and moulded into the required blanks in special steel moulds which produce a very clean product, thus requiring only small tolerances. These blanks are then annealed in electric annealers before being finally inspected.

A most satisfactory feature of the production has been the high yield per pot (55-60 per cent) of usable glass, most of it of very high quality. For example, measurements by the National Standards Laboratory of Australia have shown quite remarkable constancy in optical properties of the glass from various parts of an individual pot, combined with very satisfactory freedom from striation or other blemish. Tests on eight consecutive melts of borosilicate crown yielded a mean refractive index (Na) of 1.5100 ± 0.00023 and barely detectable differences in dispersion. Indeed, the glasses now being produced fall in properties well within the tolerances set by the Australian Optical Munitions Panel, and insure, therefore, an abundant supply of excellent material for munitions purposes.

*Reprinted by permission from "Nature," London, England, May 9, 1942.

Research Digest

Practical Interpretations of Glass Technology

Fundamental Aspects of Heat Transmission

Glass melting furnaces are rather inefficient in regard to their capacity to fully utilize their heat input. Heat balance studies show that their thermal efficiency runs between 10 and 20 per cent. Our English colleagues faced with an increasing shortage of fuel have been giving much thought to various methods of conserving fuel and in the case of glass manufacturing have been considering various means of increasing the furnace efficiency.

Smith, Roberts and Townsend (Journal Society of Glass Technology, April 1942) as their contribution toward increased furnace efficiency discuss the subject from the viewpoint of heat transmission in the furnace. The authors point out that the most important means of heating the charge is by means of radiation and that with ordinary gaseous fuels the principal sources of such radiation are the hot walls and crown of the furnace. To increase the heat transfer from this source the walls and crown must be raised to as high a temperature as is possible. In this connection important factors are the calorific value of the fuel, good mixing, and turbulent flow over the walls, the refractoriness of the furnace linings and the emissitivity of the furnace linings. This latter factor is of such importance that it may not be long before the glass manufacturer is purchasing refractory materials on the basis of their emissitivity characteristics. In fact the development of composite bricks (surface coatings on a normal brick which improve its emission properties) is one of the present trends in refractories manufacture.

With hydrocarbon-containing fuels such as oil and natural gas, increased heating by radiation may be accomplished by taking advantage of the continuous emission from the carbon particles in the flame. It was indicated that operating conditions may be more difficult, but by careful control of such factors as fuel-air ratio, stratification of air and fuel so as to obtain "diffusion" rather than "aerated" flames, and proper flame length, satisfactory working may be obtained.

In the case of insulation the authors point out that this question is still being argued pro and con but that it appeared to them, in the case of tank blocks, that by insulating the tank blocks and simultaneously reducing the rate of fuel input, it should be possible to obtain the same temperature distribution as in the uninsulated furnace, but at a reduced fuel consumption. By insulating the crown not only is the heat loss from the crown reduced but the efficiency of the furnace may be increased by the increase in radiation transfer due to the hotter crown. For example, if the temperature of the crown is 1300° C and the temperature of the glass is 1200° C an increase of 30° C in the crown temperature increases the rate of radiation from the crown by as much as 35 per cent. (In this connection American open-hearth furnace practice has shown that insulation of silica crowns is quite successful if the crown temperature is controlled.)

Selenium Decolorizing

Day and Silverman (Journal American Ceramic Society, September 1942) have studied the phenomena of selenium decolorizing by the use of spectral absorption curves of glasses containing selenium and iron, together and singly, which had been melted under various atmospheres. The results obtained show that the decolorizing action of selenium is due to a simple oxidation—reduction reaction. Under neutral or slightly oxidizing conditions the reaction is as follows:

$$Na_2SeO_3 + 4\ FeO \rightleftarrows Se^\circ + 2\ Fe_2O_3 + Na_2O$$

The decolorizing action in this case being due to the oxidation of the more colored ferrous ion to the less colored ferric ion by the colorless selenite ion with the formation of red elemental selenium which physically compensates as a complimentary color for the remaining unoxidized ferrous ion. Under reducing conditions the principal reaction is:

$$\times\ Se^\circ + 2\ FeO + Na_2O \rightleftarrows Na_2\ Sex + Fe_2O_3$$

As the melting conditions become more reducing more pink-colored selenium is formed. Reducing conditions also favor the development of a brown-colored ion. Conversely as the melting conditions become more oxidizing the pink color decreases.

Due to the arsenic situation this latter phenomena is at present of direct interest to the practical man as it explains why increases of arsenic cause a decrease in the pink color due to selenium and why more selenium is needed for good decolorizing when the arsenic is increased. This explanation of the decolorizing action of selenium indicates that it may be possible to materially decrease the amount of arsenic used without seriously affecting decolorization. The trend at present is toward the use of less arsenic and practical experience may soon prove if this theory is correct.

This theory of the decolorizing action of selenium may also be used to indicate whether or not the melting conditions are reducing or oxidizing. According to the reactions that must take place to properly explain the color changes a reducing condition is necessary for the formation of an excessive pink color. If then the ware strikes in the lehr the color change represents a continuation of the oxidation-reduction reaction and represents the reaction that must have taken place under reducing conditions.

Cast Iron for Glass Molds

At present the metal situation is such that much effort is being made to lengthen the life of glass molds through careful selection of the castings, increased care during machining and increased care during usage. The paper by Bruckner and Czyzewski (Journal American Ceramic Society, September 1942) deals with the influence of the metallurgical properties of the cast iron on its life and showed that by the proper control of casting conditions,

(*Continued on page* 442)

INVENTIONS AND INVENTORS

A Summary of United States Patents of Interest to the Glass Industry Issued During September

Composition

To avoid the hazard of fumes from phosphoric acid used in making phosphate glass, Frederick Gelstharp uses metal phosphates and particularly aluminum meta-phosphate. A typical batch composition given in his patent 2,294,844, assigned to Pittsburgh Plate Glass Co. is 65 parts aluminum meta-phosphate, 14.5 parts monopotassium phosphate and 27 per cent monomagnesium phosphate. When fused this is said to give a glass of the following composition:

75.8% P_2O_5
14.2% Al_2O_3
5.0% K_2O
5.0% MgO

A high index optical glass composition patented by Edwin Berger and Karl Rehm of Jena, Germany, contains up to 25 per cent boron oxide, up to 20 per cent lanthanum oxide and at least 45 per cent barium oxide and equivalents. The upper limits on boron and lanthanum oxides are said to be necessary to deter crystallization of the glasses. If higher acid resistance is needed, 10 per cent or more of silica may be used. This is among the first of the glass patents for which all rights will be vested in the Alien Property Custodian until post-war settlements are made. The patent was applied for Nov. 25, 1940 and is 2,297,453.

Furnaces

To eliminate the injurious dust arising in the batch feeder, George W. Batchell of Toledo proposes the unique arrangement of Fig. 1 in which certain of the batch materials are premelted and used to encompass other constituents fed in fine ground form. It will be noted that a screw conveyor feeds the powdered materials into the forebay of a comparatively small furnace from which molten glass forms an enclosing shell or tube around it. The flowing batch-filled tube is fed into the main tank. A number of variations of this main principle are described in the patent which is 2,294,373.

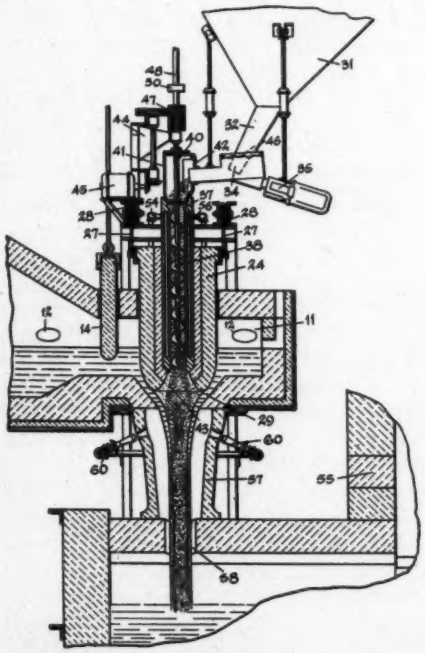


Fig. 1. 2,294,373: Batchell. To eliminate batch dust a portion of the charge is enveloped in a cylinder of molten glass made from the remainder of the batch and in this form is fed to the glass tank.

Feeding, Forming and Shaping

George B. Langer of Anderson, Ind. (Lynch Glass Corp.) has developed in patent 22,296,935 a modification for forming machines having rotary mold carriers of the type shown in Fig. 2. Since this general type of machine allows mold removal (for repairs or for changing the type of ware) only when the molds are opened, it is obvious that there would normally be only two stations at which this could be accomplished. This is frequently bothersome due to the presence of auxiliary mechanism such as conveyors or article takeout means. The molds are openable only when the cam allows the mold block rollers 16 to retreat toward the center of the cam as naturally occurs at station C. Langer has provided another mold opening and removing station on the other side of the machine at M. His method was to build a slot into the bottom of the cam at this point so that the roller 16 may slip into it and thereby allow the mold to open. The slot, which does not show in Fig. 2, is normally closed with a surface plate which is held in place by sustained air pressure. To free the slot so that a mold can be removed at station M it is necessary only to shut off the air pressure and open the exhaust cock 26.

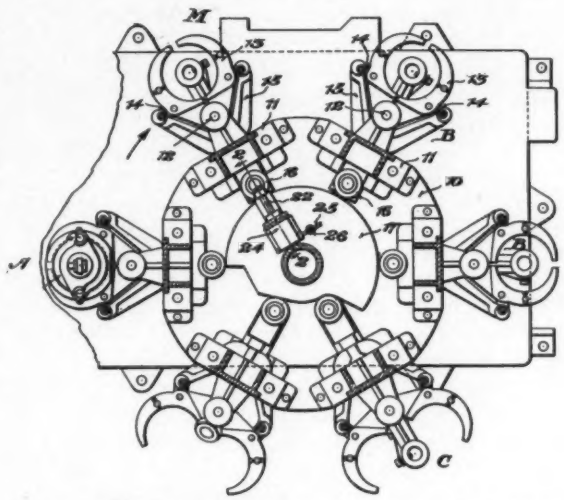


Fig. 2. 2,296,935: Langer. This rotary forming table is provided with an extra position for mold removal to get away from obstructions imposed by the takeout unit.

In patent 2,297,335 Frank H. Wheaton, Jr. of Millvale, N. J. (T. C. Wheaton Co.) tells of making ampoules by blowing in a mold a body in the shape of a bottle having a bottom and an open neck, reheating the neck

and stretching it to give the ampoule an elongated open ended stem.

For the manufacture of spirals or helices of glass rod material suitable for chemical tower packing, Edmund H. Wellach of Corning, N. Y. (Corning Glass Works) in patent 2,296,321 describes apparatus which includes means for winding a filament of plastic glass supplied from the heated end of a glass rod, or even directly from a forehearth, onto a rotating spindle, and then progressively drawing the set glass off the spindle in the form of a helix.

Miscellaneous Processes

A continuously moving table on which glass tubes or rods are mechanically cut to predetermined lengths was patented by Robert H. Houck, Joseph F. Greene and Oswald Behrend of Vineland, N. J. The machine takes lengths of tube or rod stock, holds them vertically in spaced guides, and scores them prior to dividing them into short lengths. This is patent 2,297,149 assigned to the Kimble Glass Co.

Glass building block manufacture and design is detailed in patents 2,294,776 granted to Miles E. Freeman of Saratoga Springs, N. Y., and 2,297,337 granted to Otis W. Wiley, Port Allegany, Pa. (Pittsburgh Corning Corp.) The Freeman patent concerns an unclosed block which forms a wall structure through which air is free to move vertically and horizontally. The Wiley patent describes methods of making closed glass blocks containing a fiber partition coated with vitreous enamel. While the two half-sections are still hot from shaping, the fiber partition is placed between them and they are pressed together to form the final block.

Patent 2,296,579 issued to Harry R. Seelen of Short Hills, N. J. (RCA) concerns a method of making seals for radio tubes. Glass to metal seals were the subject of another RCA patent 2,296,307 granted to Donnell W. Power of Summit, N. J. A third patent in this field is 2,296,347 issued to Ray A. Hinkley and Edmund H. Wellach of Corning, N. Y. (Corning Glass Works) for an improved base assembly for electron discharge devices.

Vitreous enamels are normally fused and then quenched in water, the latter to aid in grinding them to a powder. A group of research men of the American Radiator & Standard Sanitary Corp. have been given a patent on a process wherein the molten enamel frit from a continuous furnace is rolled into a thin sheet while it drops vertically from the furnace, and is then broken into leaf-like fragments. Rupture is brought about by slowly cooling the sheet almost to its annealing temperature, and then shattering it by the rapidly cooling action of water sprays. Enough heat is retained to allow the chips to be self-drying. This is patent 2,294,828 granted to Robert C. Boyd, Harry C. Roach and Chas. E. McNeal of Louisville.

Sheet and Plate Glass

Fig. 3 shows the proposal of Joseph Gaskell of St. Helens, England, in patent 2,296,711 (Pilkington Bros., Ltd.) for controlling the flow of glass from a forehearth to rolls. The glass flows through a spout of which the back end can be raised or lowered to vary the amount of flow.

A bending frame for governing the final shape of a glass plate bent by the influence of heating and gravity, is described in patent 2,297,315 assigned by Wm. Owen of Pittsburgh to the Pittsburgh Plate Glass Co.

The problem of properly supporting glass sheets while they are being heated and chilled for tempering seems ever with us. In this one month supporting apparatus was patented by three different groups of workers. The patents were 2,297,246 issued to Alberto Quentin of Milan, Italy, 2,297,181 to Theodor G. Weihs of Pittsburgh (American Window Glass Co.) and 2,296,691 to Delmer J. Sullivan and Gerald White of Toledo (Libbey-Owens-Ford Glass Co.). The Quentin patent provides a frame which receives the heated sheet on its emergence from the furnace and supports it resiliently, but in positive alignment while it passes between the blowers. A mere suspension from wires has led to damage of sheets due to striking blowers and other obstructions when they swing out of line. In this frame the bottom edge of the sheet rests in a spring tightened stirrup, and side wires are strung across the frame to confine the sheet. The Sullivan-White patent is particularly concerned with the

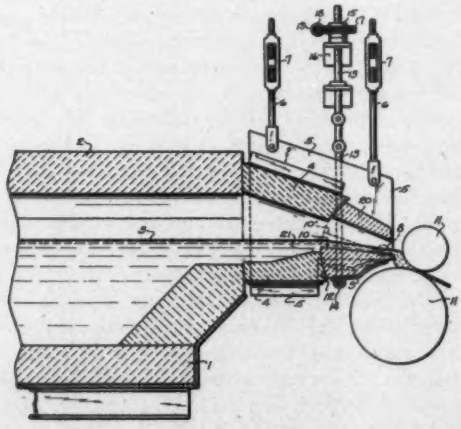


Fig. 3. 2,296,711: Gaskell. In regulating the flow of glass to rolls, the back end of the throat 10 may be raised or lowered.

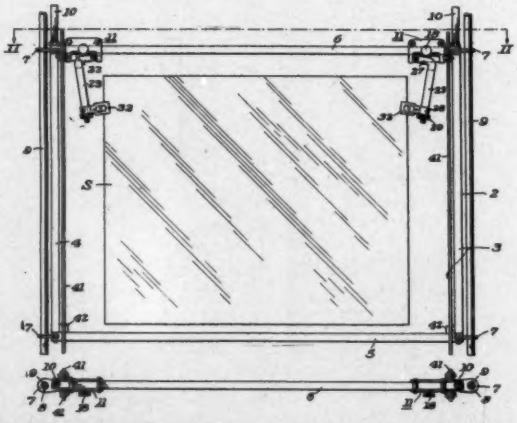


Fig. 4. 2,297,181: Weihs. Tongs 32 for use in tempering sheets are so pivoted as to divert some of the pull to a horizontal plane, to reduce tong marks.

exact placement of the gripping tongs on sheets which are to be bent as well as tempered. It is necessary that the tongs fit into the recesses provided for them in the bending molds. Provision is made for a frame on which the sheets are placed and spaced before they are lifted to the position where the tongs are fastened to them. The Weihs patent describes tongs of the type illustrated in Fig. 4 which are free for some movement either laterally due to the bearing pin in the upper end of tong arm 23, or sideways due to the rolling action of pin 22 on which the tong-arm is mounted. An advantage of this type of mounting is said to be the division of stresses so that there is a small horizontal pull. The diminishment of vertical stresses reduces the tong marks on the heated sheets.

Methods of constructing doors to utilize tempered glass slabs are described in Pittsburgh Plate Glass Co. patents 2,294,792 granted to Robert A. Miller of Tarentum and 2,294,856 granted to Geo. L. West of Pittsburgh.

Patent 2,297,417 issued to Adolf Kämpfer of Berlin (rights held by Alien Property Custodian) covers a laminated product in which the interlayer is a definite type of polymer from the group consisting of polymerized vinyl acetate and acrylic acid ester.

Glass Wool and Fiber

Fig. 5 shows the method of patent 2,294,588 for centrifugally producing glass fibers. To avoid past difficulties when the centrifugal device is too far from the glass

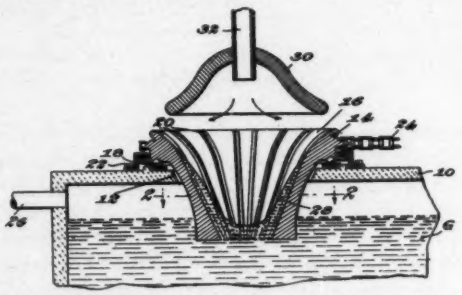
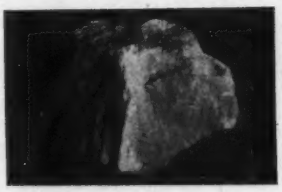


Fig. 5. 2,294,588: Pazsiczky. A centrifugal unit for throwing molten glass to form fibers is located in the forehearth instead of at some removed point to which the glass cannot be conducted without greater cooling.

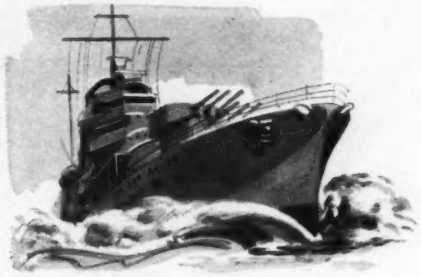
source, the inventor G. von Pazsiczky of Tamburg, Germany, brought the fiber throwing element all the way to the forehearth. The glass is drawn upwards from the supply body into a layer whose thickness gradually diminishes to the point where it is thrown outwardly from the upper edge of the gathering cup to be thereby attenuated into fine fibers.

Patent 2,295,639 issued to Daniel C. Drill of Wabash, Ind. (American Rock Wool Corp.) describes a method of throwing fibers from a corrugated air cooled drum. Another mineral wool patent is 2,295,971 (Clinton L. Savidge of Toledo; Ohio Insulation Co.) which concerns the formation of bats or matting. The fibers blown into a collecting chamber and removed on a conveyor between rolls in more or less orthodox fashion are bonded with a sheet of asphalt faced paper, the asphalt being softened for bonding purposes by the heat of the collecting chamber.

THIS LITTLE PIECE
OF DOLOMITE LIMESTONE



HELPED MAKE THIS
BATTLE WAGON



The Banner Quarry output is going almost exclusively to these four essential industries—steel, building, glass, agriculture.

Large tonnages from the Banner Quarries are used in blast furnaces and open hearth furnaces to make the steel needed for the fighting ships of Uncle Sam's Navy.

Today, steel is more important than gold. Gold mines have been closed down but the great steel mills are going "full blast." Among the essentials necessary in the making of steel is Limestone.

THAT'S WHY Banner-Lime IS
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NATIONAL MORTAR AND SUPPLY COMPANY
Grant Building, Pittsburgh, Pa.

Since 1907 . . . A good company to do business with

CURRENT STATISTICAL POSITION OF GLASS

Activity in the glass industry during September showed a slight decrease over the previous month in production, payrolls and employment. According to The Glass Industry Production Index, output during September 1942 was $38,000,000, bringing the January-September cumulative total up to $327,000,000 as compared to $338,000,000 in 1941's corresponding period. The total for September 1941 was $41,000,000.

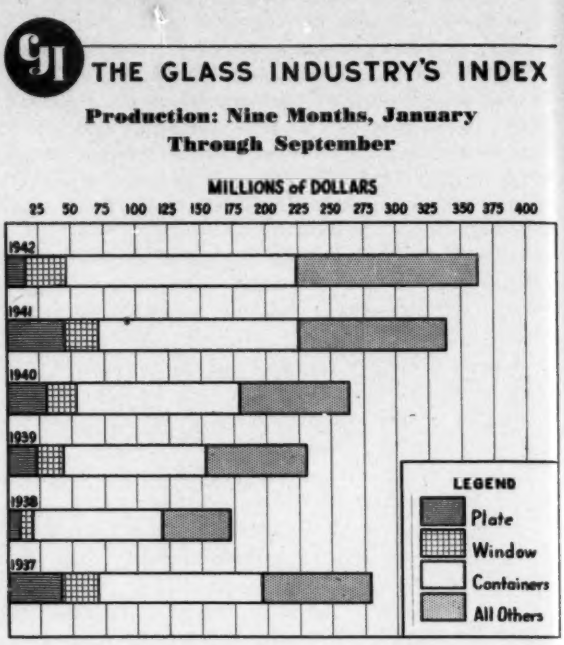
Plate glass production during September totalled 4,741,472 sq. ft. according to the Plate Glass Manufacturers of America. This was an increase of 23 per cent over the previous month's total and 63 per cent below the volume reported for September 1941. During the first 9 months of this year plate glass output amounted to 47,712,535 sq. ft. as compared to 150,047,208 sq. ft. produced in the same period last year—a decrease of 68 per cent.

Window glass production for the month of September was 1,096,883 boxes, representing 67.6 per cent of the industry capacity. Production for September 1941 was 1,123,159 boxes or 69.2 per cent of the rated capacity. The cumulative total for the January-September period was reported at 12,548,226 boxes, or an increase of 4 per cent over the same period of a year ago.

Glass container production during September totalled 6,296,991 gross, as reported by the Glass Container Association of America. This represented a decline of 5 per cent from the previous month and a slight decline over September 1941. During the first 9 months of 1942 the total was 59,777,949 gross, an increase of 17 per cent as compared to the same period in 1941.

Shipments of glass containers during September decreased approximately 1 per cent from the September 1941 total, and very slightly from August 1942, to 6,878,786 gross. However, the cumulative total for the January-September period of 1942 increased to 59,395,242 gross, or 13 per cent greater than in January-September of 1941.

The outstanding gains over September 1941 were: fruit jars—157 per cent; beer bottles—58 per cent; wide mouth food containers—26 per cent. A decrease was reported in medicinal and toilet ware of 32 per cent; pressed food ware—31 per cent; narrow neck food containers—20 per cent. The major increases over 1941 on the 9 months basis were: beer bottles—105 per cent; domestic fruit jars—64 per cent; wide mouth food containers—26 per cent.



Inventories of glass containers for September totalled 8,489,,934 gross—16 per cent greater than a year ago.

Miscellaneous glass products manufactured in September were valued at the same figure as of September a year ago, namely, $15,000,000. During the first nine months of 1942 production in this branch of the industry totalled $136,000,000 as compared to $139,000,000 in the first nine months of 1941, or a 2 per cent decrease.

According to a preliminary report of the census Bureau, twelve illuminating glassware manufacturers reported September sales totalling $712,000 which was 24 per cent under September 1941 but 10 per cent over the August 1942 total.

Automatic tumbler production during September

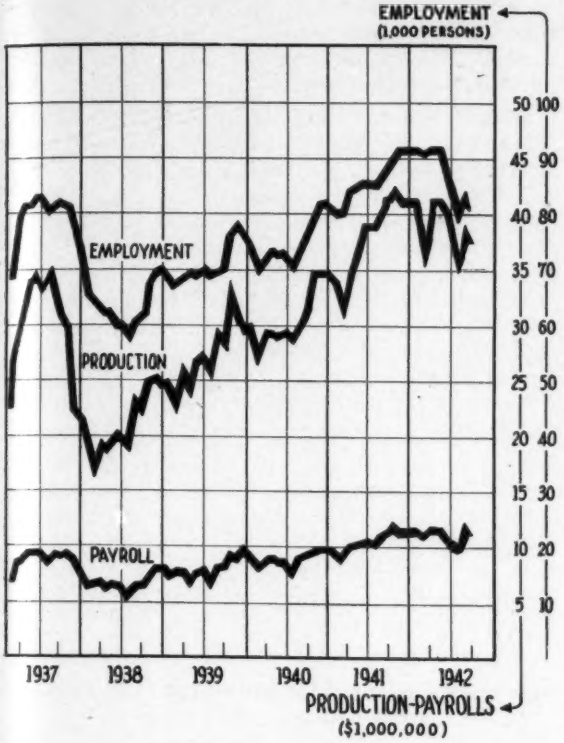
CURRENT GLASS CONTAINER STATISTICS

(ALL FIGURES ARE IN GROSS)

	Production		*Shipments*		*End of Month Stocks*	
Classifications	*Sept. 1942*	*Sept. 1941*	*Sept. 1942*	*Sept. 1941*	*Sept. 1942*	*Sept. 1941*
Food Containers (Narrow neck, wide mouth, and pressed)	2,247,652	1,956,265	2,474,376	2,322,027	2,350,954	1,740,888
Pressure and Non-Pressure Ware	301,238	353,584	314,906	330,732	329,684	454,534
Beer Bottles	574,014	364,405	636,182	401,337	280,214	503,522
Liquor Ware	1,125,933	1,124,352	1,094,826	1,074,064	1,477,497	1,366,397
Medicinal and Toilet Ware	1,159,493	1,770,722	1,286,361	1,891,380	2,988,786	2,377,291
General Purpose	383,519	344,482	360,843	417,321	590,426	392,273
Milk Bottles	264,747	331,104	285,715	342,496	330,481	291,831
Fruit and Jelly	210,647	100,696	394,615	157,765	108,675	158,041
All Other	29,748	24,153	30,962	30,767	33,217	36,398
Total Industry	6,296,991	6,369,763	6,878,786	6,967,889	8,489,934	7,321,175

GJ THE GLASS INDUSTRY'S INDEX

Monthly Trends Through September, 1942



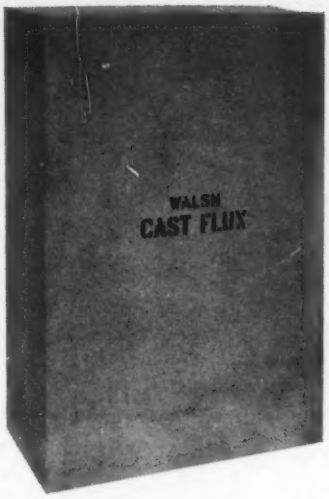
amounted to 3,859,953 dozens, or 12 per cent less than in last year's corresponding month. The January-September figures totalled 38,836,864 dozens, as compared to 39,165,362 over the same period of a year ago. Shipments for this September decreased 30 per cent from last year's figure to 3,829,029 dozens and decreased 16 per cent from the August 1942 total. Total shipments for January-September 1942 were 38,698,505 dozens and less than 2 per cent below the same nine months period of 1941. Stocks on hand amounted to 8,239,421 dozens for September, a total 14 per cent higher than in September 1941.

Manufacturers sales of machine-made table, kitchen and household glassware during September increased 6 per cent over a year ago to a total of 3,605,505 dozens. For the twelve-month period ending September 30th this trade amounted to 36,238,209 dozens as compared to a total in September 1941 of 38,397,347 dozens.

Employment and Payrolls: Employment in the glass industry during September totalled 81,000 persons as compared to 84,000 in the previous month and to 90,000 in September 1941.

Payrolls in the glass industry during September amounted to $11,000,000 as compared to $12,000,000 in August and $11,800,000 in September 1941. During the first nine months of the year glass manufacturers paid out about $107,500 in wages as compared to $96,000,000 in 1941 over the same period.

WALSH CAST-FLUX



The Vacuum-cast flux block of superior quality.

Walsh Cast-Flux blocks are machine-trued to exact size and shape after burning.

THEY LAST LONGER

The excellent results obtained in numerous tanks melting various types of glass has definitely established the efficiency and economy of Walsh Cast-Flux blocks.

Walsh Cast-Flux has a dense, uniform structure; it is burned at higher temperatures, is thoroughly bonded and possesses a low coefficient of expansion.

Walsh Cast-Flux blocks meet the most rigid requirements for tanks operating at higher temperatures . . . they insure greater tonnage, higher quality glass, freedom from defects, longer life and maximum economy.

WALSH REFRACTORIES CORPORATION

Manufacturers of Refractories for the glass industry for over 50 years

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St. Louis Missouri

JOHN T. OGDEN RETURNS

After a year of active service with the Middle East armies, John T. Ogden has returned to the United States and to resume his publishing activities as president of Ogden-Watney Publishers, Inc.

Early in 1941, before the United States entered the war, Mr. Ogden enlisted with the American Field Service, an organization that originated with World War I when it supplied some 2500 volunteer ambulance personnel and vehicles to the French Army. At the outbreak of the present hostilities in Europe, AFS sent units to Spain, Syria, and had just begun to operate in France at the time the French capitulated.

When General Wavell requested 400 ambulances and 800 men to be attached to his Middle East forces, Mr. Ogden helped to organize the first contingent for this service. As a First Lieutenant, he helped conduct these men over 24,000 miles of ocean on a voyage lasting three months to its base in Africa. Since then, until his recent return, he has been Staff Captain of the AFS, attached to GHQ, MEF. These duties took him to many parts of the war zone, including trips to Tobruk, El Alamein, Palestine and Syria. During the year he visited five continents.

GEO. L. RANDALL APPOINTED PUBLIC RELATIONS MANAGER FOR WICKWIRE

Announcement has been made of the appointment of George L. Randall as Public Relations Manager of the Wickwire Spencer Steel Company. In addition to his new assignment Mr. Randall, who has been associated with the company for seven years, will continue in charge of advertising. Mr. Randall was previously with G. Schirmer's, Music Publishers, and Warner Bros., First National Pictures.

LINCOLN FOUNDATION MAKES AWARDS FOR WELDING STUDY

The second industrial study on arc welding conducted by the James F. Lincoln Arc Welding Foundation of Cleveland, Ohio, has completed its 2½ year program, for which 408 awards totaling $200,000 were recently announced. Papers were submitted by engineers, designers, architects, maintenance men and executives throughout the industrial field.

Results of the study show the war industries have only begun to gain the benefits of modern arc welding; that arc welding will turn out vitally needed naval and military equipment which is more combat-proof, and at the same time will save an average of 300 pounds out of every ton of steel going into war production. The great mass of important new welding data contained in the papers will be made available for the benefit of war industries in the form of articles in trade publications and other magazines and eventually in book form.

Included among winners of awards in the glass industry are: J. Claude Gentry, foreman in maintenance and construction, Owens Illinois Glass Company, Alton, Illinois. Subject: Modernizing a factory; James Franklin Maine, chief engineer, Republic Structural Co., Cleveland, Ohio, and S. Cotter, Lakewood, Ohio. Subject: Five-compartment storage tank for glass manufacturing. For his paper on "Conveyors in the pottery industry" an award was made to Harry C. Hebenstreit, plant engineer, Royal China Inc., Sebring, Ohio.

NOTED METALLURGIST TO DIRECT BATTELLE RESEARCH ACTIVITIES

Announcement has been made of the appointment of Charles G. Maier to the supervisory staff of Battelle Memorial Institute, Columbus, Ohio. Mr. Maier, who has been associated with the U. S. Bureau of Mines for nearly twenty years, will direct and correlate an enlarged program of fundamental research and will serve as advisor and consultant to the Institute's war research for the government and industry.

Previous to his association with the U. S. Bureau of Mines, of which he was supervising research engineer of the Pacific Experiment Station, Mr. Maier was research fellow and subsequently assistant director of research at the University of Utah. He earlier held industrial positions with The Carborundum Company and the Phelps Dodge Corporation. He is a graduate in electrochemistry and electrometallurgy of Massachusetts Institute of Technology, 1914, and is the author of numerous journal contributions and Bureau of Mines publications.

Battelle Institute, one of the country's largest industrial research foundations, carries on fundamental and applied research in ferrous and non-ferrous metallurgy, ceramics, physics, organic and inorganic chemistry, fuels, coal preparation and utilization, ore dressing, and materials concentration.

• Dr. Cullen W. Parmelee, former professor and head of the Department of Ceramic Engineering at the University of Illinois, is now Professor Emeritus with offices in the Ceramics Building at the University.

KOPP GLASS APPOINTS RESEARCH HEAD

Kopp Glass, Inc. of Swissvale, Pa., has appointed R. Charles E. Leberknight to head their newly created Department of Research. Dr. Leberknight is a former member of the research department of the Union Switch & Signal Company and was previously an instructor in physics at Carnegie Tech.

Kopp Glass, Inc., founded by Nicholas Kopp, discoverer of Selenium red signal glass, has manufactured railroad, marine, andtraffic signal glass for over forty years. The company has recently withdrawn from making standard types of incandescent lighting glassware and is devoting its efforts to the production of technical and industrial glass specialties in which colored and heat-resisting quality glass and optical design play an important part.

GLASS CONTAINER ASS'N MEETS . . .

(*Contained from page* 420)

money for research on the part of individual glass manufacturers.

Conversion problems were discussed by Mr. F. P. Gass in considerable detail. He enumerated several of the items which have been lost to food ware as a result of restrictive orders; such as baked beans, spaghetti, homestyle pickles and dog food. Other types of glassware which have shown a decrease are those used for the packaging of such chemicals as alcohols, ammonia, boric acid, etc., and the cosmetic and toilet goods fields. Beverage ware of course has also suffered. Offsetting these losses and partly accounting for the increased volume of glass container shipments over 1941 is the gain of about 4 million gross of "No Deposit" and Quart beer bottles. Mr. Gass pointed out, however, that this was a special situation and should be disregarded from the conversion point of view. On the credit side of the ledger, it is estimated roughly that new glass container uses will increase glass container shipments by about 6½ millions gross, equal to about 8½ per cent of the year's shipments.

On labor matters Mr. Roy Blunt outlined activities in the Baltimore area. Baltimore was designated as a critical labor area and 1200 plants in that city are trying out a War Manpower Commission program designed to reduce or eliminate many of the difficulties involved in the utilization of labor both in civilian manufacturing and actual war production plants.

On the second day of the meeting Mr. Ralph Lind, Secretary of the Glass Container Industry Labor Committee, delivered an address on the over-all problems of labor in industry. His talk was quite comprehensive and included such matters as wage stabilization by Government regulation, the Overtime Compensation Order No. 9240, and the problem of Holding and Replacing of Workers.

The pressing problems under which the Glass Container Association has been operating coupled with the difficulties of doing business today did not permit quite the same degree of social activity that usually prevails at G.C.A. meetings. However, the usual air of good-fellowship and friendliness was in evidence. Respite from knotty problems was afforded by luncheons at which the members were guests of the Association. At the Thursday luncheon Capt. John T. Ogden, just returned from a year's service in the Middle East, told of some of his experiences while serving with the American Field Service attached to the British Armies.

GEORGE AURIEN

George Aurien, district sales manager of the South West territory for the Mississippi Glass Company, died October 21st. Mr. Aurien had been associated with this company since 1900 when he first served as assistant manager of the St. Louis plant and later as manager.

GLASS SLICING MACHINES

• We manufacture a variety of wet glass slicing machines for solid glass bars, glass tubing, etc. We can also supply a full line of special glass working machinery for the production of television tubes, fluorescent tubes, incandescent lamps, glass ampules and vials. Glass working lathes and laboratory equipment of all kinds. Cross Fires and Torches. Ask for our catalogue.

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CHAS. EISLER, Pres.
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GLASS COLORS • CHEMICALS

COLORS — Acid and Alkali Resistant • Transparent and Opaque • White and Colored Enamels • Weatherproof Colors • Fluxes . . . . Ices • Liquid Lustre Colors • Burnish Gold.

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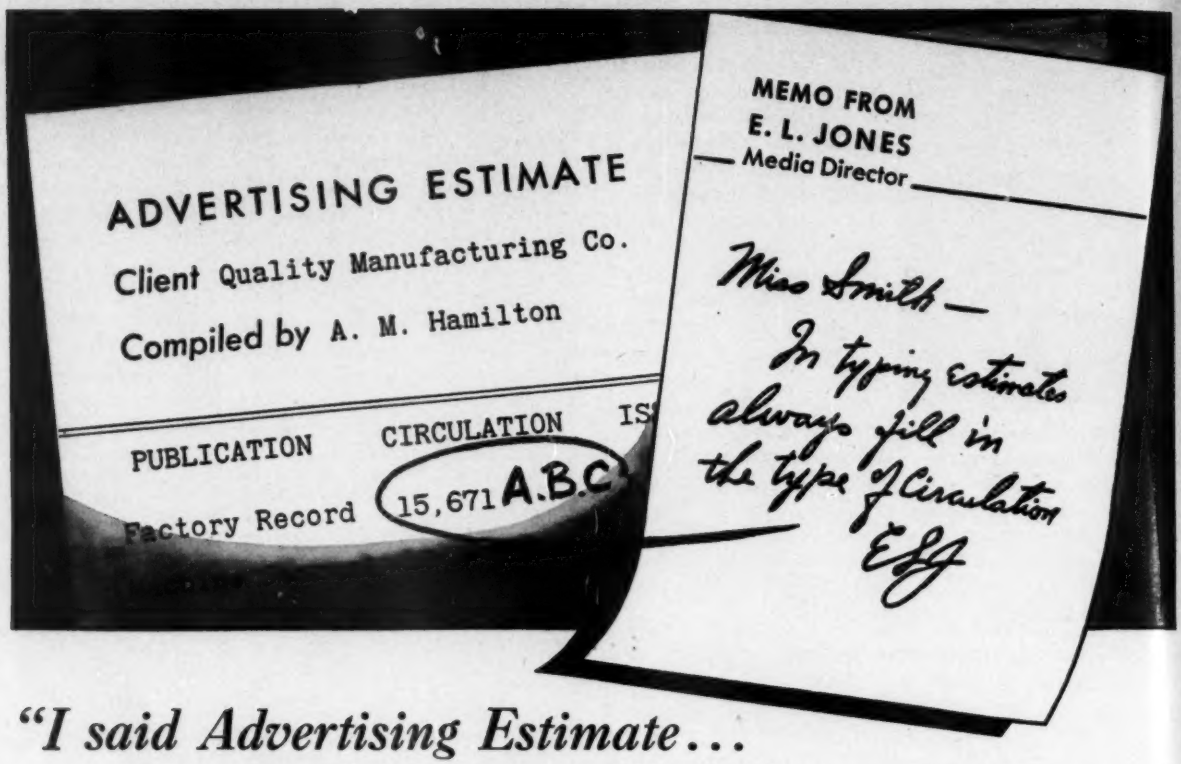

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"Circulation is the commodity the estimate covers and it's what the advertiser is paying for. We think it's good business practice to identify the type of circulation in our recommendations.

" 'A.B.C.' after the name of a publication is our clients' assurance that the selection was made on the basis of verified information. Our clients know that the facts in A.B.C. reports provide an index that permits the best use of our judgement and experience."

This paper is a member of the Audit Bureau of Circulations. We belong to A.B.C. so that we can supply facts about our circulation in accordance with the standards and terms that have been approved by advertisers and agencies. Our A.B.C. report tells how much circulation we have, how it was obtained, the business or occupational analysis of our readers, how many subscribers renew and other facts that are indispensable to effective, economical media selection and space buying.

SEND THE RIGHT MESSAGE TO THE RIGHT PEOPLE

Paid subscriptions and renewals, as defined by A.B.C. standards, indicate a reader audience that has responded to a publication's editorial appeal. With the interests of readers thus identified, it becomes possible to reach specialized groups effectively with specialized advertising appeals.

THE GLASS INDUSTRY

Member of the Audit Bureau of Circulations ABC *Ask for a copy of our latest A. B. C. report*

A. B. C. = AUDIT BUREAU OF CIRCULATIONS = FACTS AS A MEASURE OF CIRCULATION VALUES

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

Base Materials

		Carlots	Less Carlots
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	50.00	55.00
Precipitated material		55.00	60.00
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Borax ($Na_2B_4O_710H_2O$)			
Granulated	In bulk, ton	41.50	....
Granulated	In bags, ton	45.00	56.00-61.00
Powdered	In bags, ton	50.00	61.00-66.00
Boric acid (H_3BO_3)			
Granulated	In bulk, ton	95.50	
Granulated	In bags, ton	99.00	111.00-116.00
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.09½-.09¾	.10
Synthetic (Artificial)	lb.	No supplies available.	
Feldspar—(published list prices)			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags.			
Fluorspar (CaF_2) domestic, ground, 96-98% (max. SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	34.00	....
In bags	ton	36.40	50.00
Kryolith (see Cryolite)			
Lead Oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0900	....
In 5 Ton lots	lb.	....	.0950
Less than 5 Tons	lb.	....	.10
Lime—			
Hydrated($Ca(OH)_2$–MgO) (in paper sacks)	ton	8.50	9.50
Burnt (CaO–MgO) ground, in bulk	ton	7.50	....
Burnt, ground, in paper sacks	ton	9.50	9.50
Burnt, ground, in 191 lb. gross drums	Per drum	1.70	1.80
Kiln Dried ($CaCO_3$–$MgCO_3$) 10x30 mesh	ton	2.00	....
Kiln Dried ($CaCO_3$–$MgCO_3$) 16x20 mesh	ton	2.00	....
Nepheline Syenite, f. o. b. shipping point	In bulk, ton	12.00	15.00
Potassium carbonate—			
Calcined (K_2CO_3) 96-98%	lb.	.065	.0675
Hydrated 80-85%	lb.	.055	.0575
Salt cake, glassmakers (Na_2SO_4) in bags	ton	21.00-22.00	28.00-30.00
in bulk		17.50	
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	.95	....
In barrels	Per 100 lb.	1.35	....
In Paper bags	Per 100 lb.	1.10	
In Burlap bags	Per 100 lb.	1.15	....
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls. 95% and 97%	Per 100 lb.	....	3.00-3.40
Bulk	Per 100 lb.	1.35	3.60-4.00
200 lb. bags		1.4675	....
100 lb. bags		1.5025	....

Special Materials

		Carlots	Less Carlots
Aluminum hydrate ($Al(OH)_3$)	lb.	.031-.034	.045
Aluminum oxide (Al_2O_3)		.07	.09
Antimony oxide (Sb_2O_3)	lb.	.15	.15½-.16½
Arsenic			
Glassmakers	lb.	.04¼	.04¾
Regular refined white	lb.	.04	.04½
Arsenic trioxide (As_2O_3) (dense white) 99% In barrels		.04-.04¼	.04½-.04¾
Barium nitrate ($Ba(NO_3)_2$)	lb.	....	Open price.
Pyrophyllite (20% Al_2O_3)	ton	10.00	13.00
Sodium fluosilicate (Na_2SiF_6)	lb.	.06	.08
Tin Oxide (SnO_2) in bbls.	lb.	....	Open price.
Titanium Oxide (ceramic grade)			
In bags	lb.	.14½	....
In barrels	lb.	.14¾	....
Zinc Oxide (ZnO)			
American process, bags	lb.	.07¼	.07½
White Seal, 150 lb. bbls.	lb.	.09¾	.10
Green Seal, bags	lb.	.09	.09¼
Domestic White Seal, bags	lb.	.09½	.09¾
Red Seal, bags	lb.	.08½	.08¾
Zircon			
Refined Granular (Milled .01-.02c higher)		.05¾	.06

Coloring Materials

		Carlots	Less Carlots
Barium selenite ($BaSeO_3$)	lb.	....	1.40-1.60
(Commercial, 25% Selenium)	lb.	....	.85
Cadmium sulphide (CdS)	lb.	....	1.10-1.15
Cerium hydrate—			
100 lb. drums and 600 lb. barrels	lb.	....	.60
Chrome Oxide Green, 400 lb. bbls.	lb.	....	.25-.28
Chromite (99% through 200 mesh)	ton	58.25	64.75
Chromite ore (air floated)	ton	58.25	64.75
Cobalt oxide (Co_2O_3)			
In bbls. 350 lbs. or more,	lb.	....	1.84
Less than 350 lbs.,	lb.	....	1.94
Copper oxide—			
Red (Cu_2O)	lb.	....	.20-.22
Black (CuO)	lb.	....	.19-.22½
Black prepared	lb.	....	Open price.
Iron Oxide—			
Red (Fe_2O_3)	lb.	....	.06½-.10
Black (Fe_3O_4)	lb.	....	....
Iron Chromate	lb.	....	.035-.05
Lead Chromate ($PbCrO_4$) in bbls.	lb.	....	.16
Lithium Carbonate	lb.	....	1.25
Manganese, Black Oxide African			
In Paper bags	ton	70.00	78.00
In Burlap bags	ton	71.75	79.75
In Casks	ton	74.00	82.00
Neodymium oxalate, 50 lb. drums	lb.	....	4.00
Nickel oxide (Ni_2O_3), black	lb.	....	.34-.40
Nickel monoxide (NiO), green	lb.	....	.35-.37
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals and Granular	lb.	.09½	.09¾-.10
Powdered	lb.	....	.10¼-.10½
Potassium Chromate (K_2CrO_4) 100 lb. kegs.	lb.	....	.26
Powder blue	lb.	....	.21-.25
Rare earth hydrate—			
100 lb. drums	lb.	....	.35
325 lb. barrels	lb.	....	.30
Selenium (Se) in 100 lb. lots	lb.	....	1.75
In lesser quantities	lb.	....	1.85
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.07¼	.07½-.07¾
Sodium chromate (Na_2CrO_7) Anhydrous	lb.	.08¾	.08¾-.09¼
Sodium selenite (Na_2SeO_3)	lb.	....	1.50-1.65
Sodium uranate (Na_2UO_4) Orange	lb.	....	1.65
Yellow	lb.	....	1.65
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.40	3.75-4.15
Flowers, in bags	Per 100 lb.	3.05	3.40-3.80
Flour, heavy, in 250 lb. bags	Per 100 lb.	2.95	3.30-3.70
Uranium oxide (UO_2) (black, 96% U_3O_8)			
100 lb. lots. Black	lb.	....	2.55
Yellow orange	lb.	....	1.65

Polishing Materials

		Carlots	Less Carlots
Pumice Stone,			
American Ground FFF, FF, F	lb.	.04	.04½
0, 0½, ½, 1	lb.	.05	.05½
Putty Powder	lb.	Open price.	
Rotten Stone (Domestic)	lb.	.02¼	.03½
Rouge, Red	lb.	.18	.16
Black	lb.	.15	.18

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ADHERENCE OF GLASS TO METALS . . .

(*Continued from page* 423)

"oxygen bonds" these bonds do not account for the marked adherence obtained. The action of the system cobalt enamel and steel seems to be specific.

The coordination of cobalt in glass and crystalline compounds and the relation between coordination and color in cobalt glasses has been discussed and some experimental evidence has been offered which indicates that no relation exists between adherence and color in such glasses.

Bibliography

[1]W. A. Weyl, "The Replacement of Oxygen in Glass and its Effect on Adherence." The Glass Industry 23 (4) 135-137 (1942).
[2]B. E. Warren, "Summary of Work on Atomic Arrangement in Glass." Jour. Amer. Ceram. Soc. 24 (8) 256-61 (1941).
[3]W. H. Zachariasen, "The Atomic Arrangement in Glass." Jour. Amer. Chem. Soc. 54, 3841-3851 (1932).
[4]K. H. Sun & Alexander Silverman, "Glass Forming Nature of Oxides With Special Reference to Tantala, Titania, and Berylliа." Jour. Amer. Ceram. Soc. 25 (4) 97-100 (1942).
[5]W. A. Weyl, "The Constitution of Colored Glasses." Ind. Ver. (1) 107-110 (1934); Jour. Soc. Glass Tech. Abs. 18, 367 (1934).
[6]C. W. Stillwell, Crystal Chemistry, p. 278.
[7]A. Dietzel, "Significance of the Crystal Chemistry Viewpoint in Regards to the Constitution of Glasses." Naturwissenschaften 29 (5-6) 81-82 (1941).
[8]W. A. Weyl, "The Chemistry of Colored Glass." The Glass Industry 18 (3) 73-78 (1937).
[9]J. W. Grieg, "Immiscibility in Silicate Melts." Amer. Jour. of Science 13 (73) 1-44; (74) 133-54 (1927).
[10]B. E. Warren & A. G. Pincus, "Atomic Consideration of Immiscibility in Glass Systems." Jour. Amer. Ceram. Soc. 23 (10) 301-304 (1940).
[11]Kiss, Csokan & Richter, "Change in the Coordination Number as the Cause of Color Change in Solutions of Cobaltous Salts." Chem. Abs. 36 (10) 2803 (1942).
[12]G. Natta & L. Passerini, "Constitution of Rinmann Green. Thenard Blue and Other Colored Solid Derivatives of Cobalt Oxide." Gazz Chim Ital 59, 620-42 (1929); Ceram. Abs. 9 (4) 310 (1930).
[13]Gmelin Handbuch Anorganische Chemie, Teil 58; Kobalt A p. 387, 453.
[14]G. H. Spencer-Strong & R. M. King, "Mechanics of Enamel Adherence IX: Equilibrium Studies of Some Systems of Enamel Glass and Cobalt, Nickel, and Iron Oxides." Jour. Amer. Ceram. Soc. 13 (7) 208-214 (1934).
[15]E. R. Jette & Frank Foote, "A Study of the Homogeneity Limits of Wüstite (FeO) by X-ray Methods." Trans. Amer. Inst. Min. & Met. Engineers, Vol. 105, 276-289 (1933).
Jacques Bénard, "A Study of the Decomposition of Iron Protoxide and its Solid Solutions." Annales de Chemie, 11th Series, 12, 5-92, July-August 1939.
[16]R. C. Evans. Crystal Chemistry, p. 161.
[17]R. M. King, "Mechanics of Enamel Adherence XIV." Jour. Amer. Ceram. Soc. (In preparation.)
[18]A. H. Dierker, "Metal Molds for Glass Products." Glass Industry 22 (2) 61-63 (1941).

JOHN EDGAR SHULL

John Edgar Shull, 54, died October 13th at the Washington Hospital, Washington, Penna., following a lingering illness. He was employed in the Sales and Service Division of B. F. Drakenfeld & Co. Inc. for the past eleven years.

ALFRED NELSON FINN, OF NAT'L BUREAU OF STANDARDS, DIES

Alfred Nelson Finn, chief of the Glass Section of the National Bureau of Standards, Washington, D. C., and a Fellow of the American Ceramic Society, died on September 21st in Lincoln, Nebraska. Mr. Finn had been a member of the Society for twenty years, becoming an associate member in 1922 and an active member in 1924. He served on numerous committee of the Glass Division, and was secretary for four years.

LOW MELTING GLASSES . . .

(*Continued from page* 428)

On account of the empirical experience with aluminum as a stabilizing element in laboratory glass ware, the recent discovery of the effect of small amounts of aluminum ions in the attacking solution is of considerable interest. 10^{-4} equivalent per liter of Al^{+++} ions in alkaline solutions practically inhibit the continuation of alkaline attack. This almost unbelievable efficiency has been explained by Geffken as an adsorption phenomenon similar to the poisoning of a catalyst. Whenever an Al^{+++} occupies the glass surface the attacking effect is discontinued. As long as there are enough Al^{+++} ions in the liquid to cover the entire surface, the surface is completely protected.

Calcium and barium behave in a similar way. B_2O_3 does not. In the future the systematic study of the variation of the building elements in the glass, especially of silicates, borates, and phosphates, in contact with both alkaline and acidic liquids, containing a variety of similar "protective" ions, will furnish a powerful tool for the solution of our problem.

Glasses of relatively high silica content are resistive, especially towards neutral and acidic media. If superior resistivity is desirable, the alkalis more than any other basic constituents must be restricted, or if possible, eliminated. This is the case, in fiber glass where the extreme ratio surface to volume encourages chemical attack. The partial substitution of sodium by potassium and lithium has also proved to be helpful. All basic oxides of the series K_2O, Na_2O, BaO, SrO, CaO, PbO, MgO impair the resistivity somewhat, if substituted for SiO_2. The only exception of the divalent oxides seems to be zinc oxide, small additions of which are almost as favorable in their effect as SiO_2. Zinc oxide is especially advantageous against acidic and neutral media, only in alkaline media it is inferior to CaO, as it forms soluble alkali zincates.

The partial replacement of silica by alumina is advantageous. Boric acid also increases the resistivity towards neutral media, but alkali easily desintegrate glasses high in B_2O_3. The beneficial action of B_2O_3 in resistant glasses is based on the possibility to lower the alkali content without impairing meltability. TiO_2 increases the acid resistivity, but decreases alkali resistivity. ZrO_2 is claimed to make a glass resistive towards acidic, neutral as well as alkaline attack. Even though the chemistry of attack is changed considerably if borate or phosphate glasses are used instead of silicate glasses most of the previous principles are qualitatively applicable to these non-silicious glasses. Aluminum, for instance, again has been found advantageous in phosphate glasses. We have seen that Al_2O_3, and also ZnO and B_2O_3, are essential in stabilizing phosphate glasses, since the alkali and alkaline earth phosphate glasses are of rather inferior resistivity.

---

[1]Research Fellow, Monsanto Chemical Company.
[2]Ceramics Department, Pennsylvania State College.

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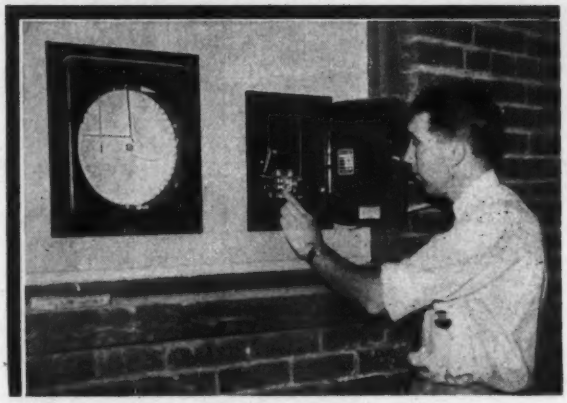

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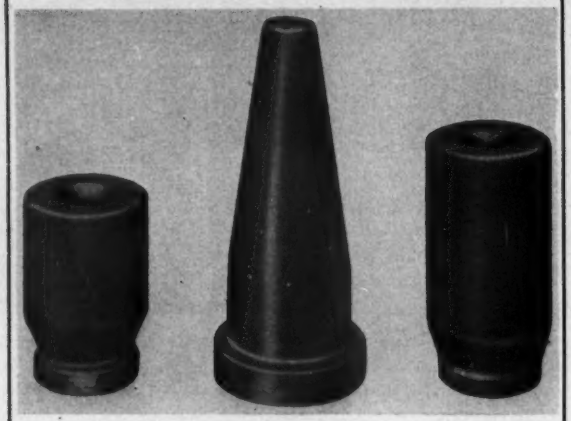

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RESEARCH DIGEST

(*Continued from page* 430)

annealing treatments and chemical composition cracking of the molds during use may be minimized.

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As alloying materials are scarce this latter iron may be impossible to obtain, the next best under present conditions therefore seems to be annealed sand-cast non-alloy irons if polish can be sacrificed for increased life.

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STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF MARCH 3, 1933.

THE GLASS INDUSTRY, published monthly at 55 West 42nd Street, New York, N. Y., for October 1, 1942, State of New York, County of New York, ss:

Before me, a Notary Public in and for the State and County aforesaid, personally appeared John T. Ogden, who, having been duly sworn according to law, deposes and says that he is the Publisher of THE GLASS INDUSTRY and that the following is to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: John T. Ogden, 55 West 42nd Street, New York, N. Y.

2. That the owners are: Ogden-Watney Publishers, Inc., 55 West 42nd Street, New York, N. Y.; John T. Ogden, 55 West 42nd Street, New York, N. Y.; Katherine Waller Ogden, 55 West 42nd Street, New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

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